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XXXIII.—*On the Freshwater Crustacea of the Indian Archipelago, with Observations on the Fauna of Freshwater in General.* By MAX WEBER *.

IMPORTANT contributions to our knowledge of the Crustacean fauna of the freshwaters of the Indian Archipelago have been furnished in the foregoing communications printed in this second volume.

Five Cladocera, two Copepods, and a Branchiopod were introduced by Herr J. Richard and six Ostracods by Herr R. Moniez, all of which were collected by myself in Sumatra and Celebes. Beyond doubt this gives us but a first glimpse of the Entomostracan fauna of the Indian islands, which is, at any rate, richer than this. It is, however, impossible sufficiently to emphasize the fact that Entomostraca are incomparably less numerous than in our European waters. It is important to observe the number of the individuals of *Daphnella excisa*, and especially of *Moina Weberi* and *Diaptomus orientalis*, which occurred only in the pelagic region of the great freshwater lakes of Singkarak and Manindjau, the altitude, extent, and situation of which were described at length in the introduction to this work. In these large basins I captured the species mentioned in thousands, together with a smaller number of *Cyclops simplex*; in the evening they were met with on the top of the water, but

* Translated from "Zoologische Ergebnisse einer Reise in Niederländisch Ost-Indien, herausgegeben von Dr. Max Weber," B.I. ii. Heft 2, Leiden, 1892, pp. 523-543.

during the day at a depth of half a metre to a metre beneath the surface. In the present communication I shall be able to add the description of a new *Argulus* to the descriptions of Entomostraca already published.

In opposition to the Entomostraca, Decapod Crustacea play an important part in the islands of Sumatra, Java, Celebes, Saleyer, and Flores visited by me. The number of species of Brachyura which I collected in these localities has been determined by Herr J. G. de Man to be thirty-four, and of Macrura thirty-five. When compared with the freshwater Decapods of Europe, which only include *Astacus*, *Telphusa fluviatilis*, *Pilumnus tridentatus*, Maitland, *Hemicaridina Desmarestii*, Millet, *Leander Edwardsii*, Heller, and *Palæmonetes varians*, Leach—the latter four of which are also found in brackish water—as well as the cave-shrimp, *Troglocaris*, the number of Decapods in the Indian Archipelago is very considerable. Not only the number of species, but also that of individuals, is very great in all lakes, ponds, rice-swamps (Sawahpfützen), and sluggish and rapid brooks and rivers, so that they give quite a distinct impress to the fauna. It will subsequently be shown in greater detail that genuine marine and also brackish-water forms, especially among the Brachyura, furnish their contingent not merely in the lower courses of the rivers, but also further inland.

Our sketch of the freshwater Crustacean fauna would, however, be left incomplete if we omitted to mention a small number of Amphipods and Isopods. It is true that these are by no means conspicuous either on account of their numbers or the frequency of their occurrence. They are, however, of interest by reason of biological peculiarities, and throw an important light on the origin of a portion of the freshwater fauna of India, whereby perhaps they also afford some elucidation of the origin of the tropical freshwater fauna in general.

In spite of extensive investigations of numerous freshwaters, I succeeded in discovering none but marine Amphipods and Isopods therein; and the exceedingly scanty statements of my predecessors, among which, as a matter of fact, the careful communications of von Martens are alone deserving of mention, furnish the same result. Again in opposition to Europe, to the fauna of which Gammaridæ and Asellidæ belong, both of these families are wanting in the Malay Archipelago. Here I found only the genus *Orchestia* in Java, Celebes, and Flores, but solely in four localities in spite of diligent searching, and, moreover, under such conditions as proved that one of the species met with had already

entirely abandoned an *aquatic* life and was existing under damp wood and stones. In the three other localities, each of which furnished a new species, the creatures had already become, at any rate, amphibious, since they also existed under stones at the edge of the water, similarly to our marine species of *Orchestia*, especially *O. cavimana*. No less a contrast to European conditions is shown in the complete absence of Asellidæ from the Malayan freshwaters. In their stead we meet with quite a number of genuine marine Isopods, which, however, are all parasites belonging to the families Cymothoidæ and Bopyridæ. Upon freshwater fishes in the Lake of Singkarah I found *Rocinela typus*, Milne-Edwards, and *Tachwa lacustris*, sp. n., the closest allied species to which was discovered by von Martens upon the coral-reefs off Singapore. In brooks and rivers far in the interior I met with the peculiar species *Ichthyoxenus Jellinghausii*, Herklots, upon Cyprinidæ, while Palæmonidæ yielded seven species of *Bopyrus*.

Can there possibly be a greater difference between the European freshwater Crustacean fauna and that of the Indian Archipelago? To this we shall be obliged to reply in the negative, and thus we come into conflict with the ever-increasing inclination to attribute a similar character to the freshwater faunæ of the globe.

To account for this inclination, reasons very different in value can be shown to exist. In the first place we have two points, which apparently might be left entirely to speak for themselves: namely, the insufficient and incomplete state of our knowledge of the local freshwater faunæ of the earth, and, further, the very imperfect determinations of the forms discovered therein, which serve as the basis for reports and communications in the form of generalizations upon the freshwaters of foreign countries. While it is precisely in such questions of animal distribution, which have a statistical character, that it is impossible to have sufficient accuracy in the determination of the genus and species, a portion of the literature dealing with freshwater faunæ is of a very preliminary kind, and could furnish nothing but altogether isolated items of evidence in favour of the thesis that the fauna of fresh water has a uniform character. Herein the one-sided prominence given to the Invertebrates, and among these again in the most marked degree to the groups with which the European investigator is acquainted from the beginning, plays a conspicuous part.

These objections are not intended to obscure the fact that an important nucleus of truth lies at the bottom of the

assumption that the freshwater fauna of the earth has in part a similar character, in so far as there are a whole number of identical species, or at any rate genera, which are widely distributed over the world. I need but recall to mind many Protozoa, Spongillidæ, *Hydra*, Hirudinea, Naidæ, Turbellaria, and various Bryozoa and Entomostraca. A common characteristic of these forms, however, is smallness of body and easy transportability occasioned thereby or by other qualifications; still more, however, such a constitution of their germs that these can sustain changes of temperature and drought, and by means of wind or other mode of conveyance can be readily transferred from one freshwater station to another. Pregnant instances of this are already recorded in numbers in the writings of Darwin, Forel, Semper, and Zacharias, and in the latest suggestive work of Simroth*, and are known to everyone. It is enough to remind the reader of encysted Protozoa which are carried away in the mud on the feet of birds and also in their droppings; or of the shell-protected egg of *Hydra*, which like *Hydra* itself is easily transported. Species may also be carried by means of leaves, which are caught up by the wind from a pool which is drying up, as I observed in the case of Spongillidæ in India. The gemmulæ of freshwater sponges are, as is well known, especially fitted for such and similar modes of transport; this applies in quite a peculiar degree to those of *Spongilla decipiens*, a species described by myself, the numerous gemmulæ of which, surrounded by tissue containing air, float upon the water equally as well as the statoblasts of Bryozoa, which I likewise met with in abundance in India. All these germs, precisely like the "winter" eggs (Dauereier) of the Cladocera in their ephippia, are driven or wafted to the shore as they float upon the surface of the water, and are then an easy sport of the winds or other transporting medium.

It has only recently been shown by de Guerne † how Hirudinea are carried by birds, while Blanchard ‡ and Megnin § have pointed out that a similar result is also brought about by mammals.

All the species mentioned hitherto, which in one form or another are readily transported, and for this reason alone, apart from any other, may be more generally distributed over the earth, we will term "*universal*" freshwater animals. Besides these the freshwaters of the different districts contain

* Simroth, 'Entstehung der Landthiere.' Leipzig, 1892.

† J. de Guerne, Comptes Rendus hebdomadaires de l'Académie des Sciences, 1892, p. 92; and Ann. Mag. Nat. Hist. ser. 6, vol. x, pp. 117-120.

‡ Blanchard, Bull. Soc. Zool. de France, xvi. 1891, p. 218.

§ Megnin, Bull. Soc. Zool. de France, xvi. 1891, p. 222.

local species in varying numbers and variety, or, at least, such as have a more restricted area of distribution. To these forms we will apply the designation "*regional*" freshwater animals. The question now arises whence these latter are derived, and how their more limited distribution is to be explained.

In connexion with this question various considerations have to be taken into account, which at present render it impossible to return a comprehensive answer. For instance, it is difficult to account for the fact that *Apus* and *Branchipus* are absent from the Indo-Malayan region, although the eggs of both genera are so exceptionally constituted for being carried about from place to place.

It is above all among Vertebrates, Mollusks, and Malacostracous Crustacea that the forms occur which are not universally distributed. I need but refer to Urodeles, which with the exception of the Cœcilians are absent from the tropics and the southern hemisphere; or to the regional occurrence of Ganoids, Dipnoi, Siluroids, Labyrinthici, and other freshwater fish. Allusion may also be made to the Astacidæ, Palæmonidæ, and freshwater Brachyura, while the absence of Asellidæ and Gammaridæ in the Indo-Malayan region may likewise be pointed out.

Now Vertebrates, Mollusks, and the Crustaceans mentioned are all animals of some size, which for this reason alone could not or could hardly be carried about. The same applies to their eggs, which are not suited for passive dissemination. Herein we already have a conspicuous reason for their to a certain extent emphatically regional distribution.

Here and there we find the idea expressed that the above-mentioned denizens of fresh water, to which we have applied the term "*universal*," are of especially high geological antiquity, which may be taken as a partial explanation of their wide distribution.

In many cases this may certainly be correct. I shall, moreover, attempt to show directly that as a matter of fact, as opposed to the more ancient forms, there are also more recent freshwater animals, which evidently derive their origin from the sea. But to contrast the whole of the "*universal*" freshwater forms, as being geologically the more ancient, with the "*regional*" ones, as geologically more recent, would undoubtedly, in such general terms, be incorrect. Why among universal forms *Spongilla*, for instance, and many Entomostraca or Bryozoa are to be considered historically more ancient than perhaps *Apus*, *Branchipus*, *Asellus*, *Gammarus*, Dipnoi, Ganoidei, and Urodeles, it is certainly impossible to perceive. Lower organization of a species is

not in itself a proof of greater antiquity. In the case of more lowly organized animals the formation of species is no more limited in time than in that of more highly organized forms.

Now in my opinion it is possible to demonstrate the marine origin of a considerable fraction of the freshwater animals which are of regional occurrence. Naturally I am not speaking here of the hypothesis that in the end all freshwater animals are derived from the primeval ocean.

In the first instance I am thinking of the "relic-animals" (Relieten-Thiere), yet only in the sense in which they are so regarded by Lovén and Credner. Accordingly I consider as "relics" only such animals as are really of a marine nature and inhabit freshwater basins, that can be proved by geology to have been once filled with sea-water and to have been in connexion with the ocean. The numerous "relic-lakes," with which zoological fancy has covered the earth, for the most part do not bear geological criticism, any more indeed than they sustain more precise zoological examination. Besides a number, small it is true, of genuine marine relics, fresh water is peopled by numerous marine forms; these, however, have not been "left behind," but are *immigrants*, *active* or *passive*, as the case may be.

I would therefore divide the freshwater fauna as follows :—

1. Universal freshwater animals.
2. Regional
 - a. Local genuine freshwater animals, which form an already ancient stock.
 - b. Marine forms.
 - a. Relics.
 - β. Immigrants.
 - β₁. Active immigrants.
 - β₂. Passive „

The larger portion of these immigrants wander actively from the sea into the brackish estuaries and further into the lower course of the rivers, to gradually ascend until they penetrate far into the interior. From the nature of the case the rôle played by passive immigrants is a subordinate one, since they are carried almost exclusively as parasites from the sea into the rivers, and in this manner finally also reach the lakes, like *Tachæa lacustris* and *Rocinela typus*, which will be dealt with later on. A certain participation on the part of the animal that is passively transported is self-evident.

The communications of Günther, Sauvage, von Kennel, and Stuhlmann already point to the fact that the marine immigrants in the tropics at any rate play an important part, as is even still the case; for I am convinced that

immigration is still taking place at the present time, and that it shows us the process of the formation of the freshwater fauna *.

I should like to prove this by means of the Crustacean fauna of the freshwaters of the Indian Archipelago; for my material bearing upon this question is already accurately worked out, and was collected by myself with my own hands, with the exception of the Crustacea of Timor and Rotti, for which I am indebted to my fellow-traveller Prof. A. Wichmann, of Utrecht. Since, however, the latter was well acquainted with the questions which interested me, I have before me absolutely precise statements with reference to the origin of these specimens also. The latter point is of paramount importance in this question, in which we have to consider the nature of the water, whether fresh, brackish, or sea-water, in which the animals were collected.

If the specimens were obtained in the lower course of a river, it is necessary to notice whether any and what change takes place in the water in that portion of the stream at flood-tide. Close attention was paid to all these points.

Now since such observations were not, or not to a sufficient extent, connected with the Crustacea previously collected in the Indian Archipelago, I was hardly able to derive further statements from the literature on the subject. A solitary exception is constituted by the excellent communications of E. von Martens, to whom altogether we owe the most comprehensive and best information, not merely for the Indian Archipelago, upon this subject. For the rest I depend exclusively upon my own experience.

The following list of the freshwater Crustacea of the Indian Archipelago gives at once statements as to their occurrence in the different islands:—Sumatra (S.), Java (J.), Borneo (B.), Celebes (C.), Saleyer (Sal.), Flores (F.), Timor (T.), and the Moluccas (M.); as also as to their occurrence in fresh, brackish, or sea-water, or upon the land in damp surroundings.

Certain species, which are absent from my collection, and as to which I have no personal experience, are indicated by spaced type. The statements in brackets—(), []—as to occurrence imply that the observations in question do not emanate from me.

This list will be followed by a few remarks and conclusions, as well as by a description of the Argulidæ, Isopoda, and Amphipoda which I collected.

* With regard to these questions, I consider it my duty to remind the reader of the valuable but largely forgotten paper by Rüttimeyer—'Ueber die Herkunft unserer Thierwelt,' 1867, p. 17.

Freshwater Crustacea of the Indian Archipelago.

	Fresh Water.	Land.	Brackish Water.	Sea-Water.	
BRANCHIOPODA.					
1. <i>Cyclestheria Hislopi</i> , <i>Baird</i> ..	*	..	..	..	C.
CLADOCERA.					
2. <i>Daphnella excisa</i> , <i>Sars</i>	*	..	..	..	S.
3. <i>Moina Weberi</i> , <i>Richard</i>	*	..	..	..	S.
4. <i>Macrothrix spinosa</i> , <i>Sars</i>	*	..	..	..	C.
5. <i>Ilyocryptus longiremis</i> , <i>Sars</i> ..	*	..	..	..	C.
6. <i>Alona Sarsi</i> , <i>Richard</i>	*	..	..	..	C.
OSTRACODA.					
7. <i>Cypris Weberi</i> , <i>Moniez</i>	*	..	..	..	C.
8. — <i>Richardi</i> , <i>Moniez</i>	*	..	..	..	C.
9. — <i>odiosa</i> , <i>Moniez</i>	*	..	..	..	C., S.
10. — <i>Sarsi</i> , <i>Moniez</i>	*	..	..	..	C.
11. <i>Stenocypris Malcolmsonii</i> , <i>Brady</i>	*	..	..	..	C.
12. <i>Cyprinotus pyxidatus</i> , <i>Moniez</i> ..	*	..	..	..	C.
COPEPODA.					
13. <i>Cyclops simplex</i> , <i>Poggenpol</i>	*	..	..	..	S., C.
14. <i>Diaptomus orientalis</i> , <i>Brady</i> ..	*	..	..	..	S.
BRANCHIURA.					
15. <i>Argulus indicus</i> , <i>M. Weber</i>	*	..	..	..	J.
ISOPODA.					
16. <i>Ichthyoxenus Jellinghausii</i> , <i>Herklots</i>	*	..	..	..	S. [J.]
17. <i>Tachæa lacustris</i> , <i>M. Weber</i> ..	*	..	..	..	S.
18. <i>Rocinela typus</i> , <i>Milne-Edwards</i>	*	..	..	(*)	S. [B., Bay of Bengal.]
19. <i>Palægyge Borrei</i> , <i>Giard &</i> <i>Bonnier</i>	*	..	..	..	F.
20. — <i>fluviatilis</i> , <i>M. Weber</i>	*	..	..	..	C.
21. — <i>Bonnieri</i> , <i>M. Weber</i>	*	..	..	..	C., F., T.
22. —, sp.	*	..	..	..	F.
23. —, sp.	*	..	..	..	F.
24. — <i>de Mani</i> , <i>M. Weber</i>	*	..	..	..	S.
25. <i>Probopyrus Giardi</i> , <i>M. Weber</i> ..	*	..	..	..	S.

Freshwater Crustacea of the Indian Archipelago (continued).

	Fresh Water.	Land.	Brackish Water.	Sea-Water.	
AMPHIPODA.					
26. <i>Orchestia floresiana</i> , <i>M. Weber</i> ..	*	*	..	..	F.
27. — <i>Martensii</i> , <i>M. Weber</i>	*	*	..	..	F.
28. — <i>parvispinosa</i> , <i>M. Weber</i> ..	..	*	..	..	J.
29. — <i>montana</i> , <i>M. Weber</i>	*	*	..	..	C.
DECAPODA.					
30. <i>Cardisoma carnifex</i> , <i>Herbst</i>	..	*	*	*	C., F.
31. <i>Geotelpusa Kuhlii</i> , <i>de Man</i> ..	*	*	..	..	J.
32. — <i>sumatrensis</i> , <i>Miers</i>	*	*	..	..	S.
33. <i>Telpusa granulata</i> , <i>de Man</i> ..	*	*	..	..	J.
34. — <i>Larnaudii</i> , <i>Milne-Edw.</i> , var. <i>brevimarginata</i> , <i>de Man</i>	*	*	..	..	J., S.
35. — <i>celebensis</i> , <i>de Man</i>	*	..	..	..	C.
36. <i>Paratelpusa tridentata</i> , <i>Milne-Edwards</i>	*	..	..	..	J. [T., Solor.]
37. — <i>convexa</i> , <i>de Haan</i>	*	..	..	..	J. [T., New Guinea, Solor.
38. — <i>maculata</i> , <i>de Man</i>	*	..	..	..	S. Borneo.]
39. <i>Oecypode cordimana</i> , <i>Latreille</i> ..	*	..	..	*	F. [Generally distributed.]
40. <i>Gelasimus acutus</i> , <i>de Man</i>	..	..	*	*	S., C.
41. — <i>triangularis</i> , <i>Milne-Edw.</i> ..	..	..	*	*	S.
42. — <i>coarctatus</i> , <i>Milne-Edwards</i> ..	..	..	*	*	C.
43. <i>Varuna literata</i> , <i>Fabricius</i>	*	..	*	*	S., C., Sal., F., T.
44. <i>Utica gracilipes</i> , <i>White</i>	*	..	*	..	F.
45. <i>Pseudograpsus barbatus</i> , <i>Rumph.</i>	*	..	..	..	F.
46. — <i>crassus</i> , <i>Milne-Edwards</i> ..	*	..	..	..	F.
47. <i>Pyxidognathus granulosus</i> , <i>Milne-Edwards</i>	*	..	..	..	F.
48. <i>Ptychognathus dentatus</i> , <i>de Man</i>	*	..	..	..	C.
49. — <i>Riedelii</i> , <i>Milne-Edwards</i> ..	*	..	..	..	F., C.
50. — <i>glaber</i> , <i>Stimpson</i>	*	..	..	(*)	F.
51. — <i>pusillus</i> , <i>Heller</i>	*	..	..	(*)	F. [Malay Archipelago.]
52. — <i>pilipes</i> , <i>Milne-Edwards</i> ..	*	..	..	..	T.
53. <i>Sesarma melissa</i> , <i>de Man</i>	*	..	*	(*)	F.
54. — <i>bidens</i> , <i>de Haan</i>	..	..	*	*	C.
55. — <i>impressa</i> , <i>Milne-Edwards</i> ..	*	..	..	(*)	F.
56. — <i>Edwardsii</i> , <i>de Man</i>	*	..	..	(*)	F.
57. — <i>Lafondii</i> , <i>Homb. & Jacq.</i> ..	*	..	..	(*)	S.
58. — <i>Smithii</i> , <i>Milne-Edwards</i> ..	*	..	..	*	
59. — <i>Moeschii</i> , <i>de Man</i>	*	..	..	(*)	S.
60. — <i>frontalis</i> , <i>Milne-Edwards</i> ..	*	..	..	(*)	F.
61. — <i>trapezoides</i> , <i>Guérin</i>	*	..	..	(*)	F.
62. — <i>Weberi</i> , <i>de Man</i>	*	..	*	..	F.
63. — <i>maculata</i> , <i>de Man</i>	*	*	*	..	F.
64. <i>Geosesarma nodulifera</i> , <i>de Man</i>	*	..	..	..	J.
65. —, <i>sp.</i>	*	*	..	..	J.

Freshwater Crustacea of the Indian Archipelago (continued).

	Fresh Water.	Land.	Brackish Water.	Sea-Water.	
66. <i>Geosesarma</i> , sp.	*	..	..	..	C.
67. — <i>sylvicola</i>	..	*	..	..	S.
68. <i>Metasesarma</i> Rousseauxi, <i>Milne-Edwards</i>	*	..	?	(*)	F. [Malay Archipelago.]
69. <i>Remipes testudinarius</i> , <i>Latreille</i>	*	..	(*)	(*)	F., T., C.
70. — <i>denticulatifrons</i> , <i>White</i> ..	*	..	(*)	(*)	T.
71. <i>Acy</i> moluccensis, <i>de Haan</i> ..	*	..	..	..	Generally distributed.
72. — <i>brevirostris</i> , <i>de Man</i>	*	..	..	..	F., T.
73. — <i>Gustavi</i> , <i>Ortman</i>	*	..	..	..	S.
74. — <i>dentirostris</i> , <i>Thalwitz</i> ..	*	..	..	..	C.
75. <i>Caridina typus</i> , <i>Milne-Edwards</i>	*	..	..	..	F., Sal., C.
76. — <i>Weberi</i> , <i>de Man</i>	*	..	..	..	F., Sal., C., S.
77. — <i>parvirostris</i> , <i>de Man</i>	*	..	..	..	F.
78. — <i>laevis</i> , <i>Heller</i>	*	..	..	..	J.
79. — <i>multidentata</i> , <i>Stimpson</i> ..	*	..	..	..	C.
80. — <i>parepareasis</i> , <i>de Man</i>	*	..	..	..	C.
81. — <i>serratirostris</i> , <i>de Man</i>	*	..	..	..	F., Sal., C.
82. — <i>Wyckii</i> , <i>Hickson</i>	*	..	*	..	F., Sal., C.
83. — <i>brevicarpalis</i> , <i>de Man</i>	*	..	..	..	C., F.
84. — <i>gracilirostris</i> , <i>de Man</i>	*	..	*	..	C., F., Sal., S.
85. <i>Alpheus rapax</i> , <i>Spence Bate</i> ..	*	..	..	*	C.
86. <i>Palæmon carcinus</i> , <i>Fabricius</i> ..	*	..	*	*	Generally distributed.
87. ? — <i>Rosenbergii</i> , <i>de Man</i> ..	?	..	?	?	[New Guinea.]
88. — <i>Weberi</i> , <i>de Man</i>	*	..	..	..	C.
89. — <i>dispar</i> , <i>von Martens</i>	*	..	..	..	Widely distributed.
90. — <i>sundaicus</i> , <i>Heller</i>	*	..	*	..	J., F., C.
91. — <i>elegans</i> , <i>de Man</i>	*	..	..	..	J.
92. — <i>lar</i> , <i>Fabricius</i>	*	..	*	..	Generally distributed.
93. — <i>equideus</i> , <i>Dana</i>	*	..	..	*	S.
94. — <i>javanicus</i> , <i>Heller</i>	*	..	..	..	J., B., S., C.
95. — <i>Horstii</i> , <i>de Man</i>	*	..	..	..	C.
96. — <i>scabriculus</i> , <i>Heller</i>	*	..	..	..	Sal., C.
97. — <i>endeensis</i> , <i>de Man</i>	*	..	*	..	F.
98. — <i>modestus</i> , <i>de Man</i>	*	..	..	..	F.
99. — <i>pilimanus</i> , <i>de Man</i>	*	..	..	..	S., J.
100. — <i>latimanus</i> , <i>von Martens</i> ..	*	..	*	..	T., F., Rotti, Adonare,
101. — <i>placidus</i> , <i>de Man</i>	*	..	..	..	S. Amboina.
102. — <i>placidulus</i> , <i>de Man</i>	*	..	..	..	Sal., C., F., T.
103. — <i>lampropus</i> , <i>de Man</i>	*	..	..	..	C., T.
104. — <i>bariensis</i> , <i>de Man</i>	*	..	..	..	F.
105. — <i>lepidactyloides</i> , <i>de Man</i> ..	*	..	..	..	F.
106. — <i>latidactylus</i> , <i>Thalwitz</i> ..	*	..	..	..	C.
107. — <i>idæ</i> , <i>Heller</i>	*	..	..	..	B., J.
108. — <i>esculentus</i> , <i>Thalwitz</i> ..	*	..	..	..	C.
109. — <i>dulcis</i> , <i>Thalwitz</i>	*	..	..	..	C.
110. <i>Miersia compressa</i> , <i>de Haan</i> ..	*	..	..	..	Adonare.
111. <i>Leander concinnus</i> , <i>Dana</i>	*	..	*	(*)	C., Sal., F.
112. <i>Pengus monocerous</i> , <i>Fabricius</i> ..	*	..	*	*	C.

The above list suggests the following remarks and conclusions:—

To the relative paucity of Entomostraca allusion has already been made. Even though they are undoubtedly more numerous than this list would lead us to suppose, they are nevertheless of very much less frequent occurrence than in European waters. *Branchipus* and *Apus* too are absent; for, even if Entomostraca have not been described hitherto from the region with which we are dealing, still the two genera in question, had they been present, must by reason of their size have attracted the attention of previous investigators also. But neither did von Martens meet with them in the Indian Archipelago, nor did Semper observe them in the Philippines.

An important lesson is taught us by the Isopods.

In the first place, Asellidæ are entirely wanting, as also Sphæromidæ, certain species of which are likewise known from fresh water. *The whole of the species observed by me are exclusively stationary or permanent parasites, and belong either to marine species, to marine genera, or, at least, to marine families.*

Of Cymothoinæ our list includes *Ichthyoxenus Jellinghausii*, Herklots, *Rocinela typus*, Milne-Edwards, and *Tachæa lacustris*, sp. n.

Ichthyoxenus Jellinghausii was previously found in Java, and I met with it myself in rivers in Sumatra upon species of *Puntius*. A second species, *Ichthyoxenus montanus*, Schiödte and Meinert, is known from rivers in the Himalayas as parasitic upon *Puntius sophore*.

A single specimen of *Rocinela typus*, Milne-Edwards, was met with by von Martens in Borneo, in the Kapuas River near Sintang, upon *Notopterus hypselonotus*, a freshwater fish. I obtained numerous specimens from Cyprinoids in the Lake of Singkarah, at an altitude of 362 metres above the sea. Before this *Rocinela typus* was collected in the Bay of Bengal.

It is certainly by no means hazardous to suppose that this species, which belongs to an entirely marine genus, is also capable of sojourning upon such marine fishes as visit the mouths of rivers. It can be proved that *Rocinela typus* temporarily leaves the fish in order to live upon the bottom, for the sake of reproduction and perhaps also of undergoing ecdysis. In seeking out a new fish our parasite may easily attach itself to one of the numerous river-fishes which at the same time also visit the brackish estuary, and thus gradually for generations adapting itself to fresh water become a fresh-

water animal. The freshwater form described by von Martens and myself perhaps also already differs somewhat from the marine form. At any rate, it follows that we are acquainted with this species from the sea (Bay of Bengal), from a river (Kapuas River), and from an elevated freshwater lake (Lake of Singkarah). Passive immigration—of course with a certain amount of assistance on the part of the animal itself—may therefore probably be assumed in this case also.

The occurrence of *Tachwa lacustris*, sp. n., upon Cyprinoids, likewise in the Lake of Singkarah, is to be explained in a similar manner. This new species differs but little from *Tachwa crassipes*, Schiödt and Meinert, which von Martens discovered upon the coral-reef of Singapore, consequently under conditions as marine as possible.

According to the mode of explanation which has prevailed hitherto the Lake of Singkarah consequently contained two most excellent examples of genuine relic-animals; later on we shall be able to indicate yet other marine forms from the same locality. An immigration on the part of these animals into this lake is, however, the much more natural explanation of their presence, and is at the same time in accordance with the geological facts, which furnish no proofs that the region of the lake, either during or subsequent to the formation of its basin, was inundated by the sea, or that the lake was at any time filled with sea-water.

Moreover other species of Cymothoinæ are known, which have become adapted to freshwater life, but occur especially in the lower courses and at the mouths of rivers—indications that it is immigration with which we are dealing in this instance.

Besides my three species mention must be made of *Ichthyoxenus montanus*, Schiödt and Meinert, already alluded to, from rivers of the Himalaya; also of two species that apparently are allied to this—*Lironeca laticauda*, Miers, from Manchuria, and *Lironeca daurica*, Miers, from the River Onon in South-east Siberia—and, further, of *Cymothoa amurensis*, Gerstf., in Siberian rivers, and *Asotana formosa*, Sch. & Mein., from the River Iça in Peru.

The following species were found at the mouths of rivers, or, at any rate, in the adjoining lower portion of the stream:—*Nerocila fluviatilis*, Sch. & Mein., in the Rio Plata near Monte Video; *Lathræna insidiosa*, Sch. & Mein., in the mouth of the River Santos, in Brazil, upon *Centengraulis edentulus*; *Telotha lunaris*, Sch. & Mein., in the Rio das Velhas, Brazil, upon *Sternarchus brasiliensis*, Rht.; *Telotha Henselii*, v. Mart., in a river near Porto Alegre, Brazil, upon

a species of *Geophagus*; *Cirolana elongata*, H. M.-Edw., in the mouth of the Ganges; while *Olencira prægustator*, Latrobe, lives upon the coast of North America, but is found besides in rivers in that region. With regard to *Glossobius laticauda*, M.-Edw., it is stated by Schiödte and Meinert that it is found in all warm seas upon species of *Exocætus*, and when we find the River Continguiba (Maroin) included among the localities, we can only conclude that the authors are here speaking of the mouth of the river, which is probably the only portion sufficiently salt to enable *Exocætus* still to exist in it*.

Now if we further consider that, besides numerous marine species which are inexactly described, we have, especially owing to the work of Schiödte, Meinert, and Hansen, a more precise knowledge of over one hundred and eighty species of Cymothoinæ, we shall be obliged to regard this family as genuinely marine, and from the statements and *résumés* given above we may conclude that an immigration into fresh water is partly in progress and partly, as in the case of the three Indian species *Ichthyoxenus Jellinghausii*, *Rocinela typus*, and *Tachæa lacustris*, already completed.

In our list there also appear two genera nearly allied to the genus *Bopyrus*, with at least seven species. Semper was the first to announce the occurrence of *Bopyrus* in the fresh water of the Philippines. Thereupon Giard and Bonnier described *Probopyrus ascendens* and *Palægyge Borrei*, two species which were found living upon freshwater Palæmonids in the Indian Archipelago—the former upon *Palæmon lar*, Fabr., and the latter upon *P. dispar*.

To these I am consequently able to add further forms living upon other species of the genus *Palæmon*.

It is well known that the family Bopyridæ is thoroughly marine. Our potamophilous species must therefore be immigrants into fresh water, and this at the same time implies the assertion that the genus *Palæmon* has also penetrated from

* It is true that J. v. Kennel ('Arbeiten a. d. Zool. Institut zu Würzburg,' 1883, p. 276) mentions "a Crustacean belonging to the genus *Æga*" as having been found by himself in fresh water upon the island of Trinidad; but no indication whatever of the species is given, as is much to be desired in this case, considering the very ambiguous use that is made of the name *Æga*. Von Kennel states that the occurrence of *Æga* in the fresh water of the Palau Islands had already been made known by Semper, and this is also repeated by Simroth. In spite of much search, I have not been able to find the statement alluded to. In Semper's 'Existenzbedingungen der Thiere' (p. 102) a blind "Cymothoon" from "slightly brackish water" is certainly figured, but the genus to which it belongs is not determined.

the sea into the rivers and lakes. For since each species of *Bopyrus* is attached to a distinct species of *Palæmon*, with a regularity which, according to Giard, is characteristic of the Epicaridæ in general, we cannot suppose that the progeny of a Bopyrid whose host was a *Palæmon* which perhaps frequented the vicinity of the mouth of a river, made their way into a genuine river-*Palæmon*. The truth must rather be that *Bopyrus* has immigrated with *Palæmon*, and that the subsequent development of species of the latter has been accompanied by a parallel development of species among the Bopyridæ.

The Isopod freshwater fauna in the Indian Archipelago consequently differs altogether from that of Europe, and consists exclusively of marine forms, although the precise method of their immigration from the sea is not directly obvious.

Of the order Amphipoda our list includes only the genus *Orchestia*, with four species. There appears to be a lack of statements as to the occurrence of Amphipoda in the fresh water of the Indian Archipelago, which is probably in itself a proof of their rarity. Moreover it was only in four localities, widely distant one from another, that I succeeded in discovering the species which are described below.

To reflect, however, that the fauna of the Indian islands has been augmented by a few new members is to regard these four new species of *Orchestia* from the less interesting point of view. The following considerations are of greater importance.

Orchestia floresiana was taken by me near Maumeri, on the north coast of East Flores, in and under fallen leaves at the edge of a pool of fresh water, which lay in a small copse at a distance of about 100 metres from the beach.

On the south coast of the same island I found in the neighbourhood of the village of Lella, in the small stream of the same name, a few hundred metres distant from its mouth and in perfectly fresh water, *Orchestia Martensii* under stones, some in the stream itself, others on the bank. Both species have consequently become adapted to fresh water and at the same time to a mode of life that is to a certain extent amphibious, since they also exist outside the water, beneath damp leaves and stones.

Similar to this was the mode of life of *Orchestia montana*, which I met with near Loka at an altitude of 1150 metres, in the highlands near Bonthain (Celebes), in direct proximity to a mountain-stream.

Finally, I captured the fourth species, *Orchestia parvispinosa*, beneath the trunk of a fallen tree and under stones

at the side of a road in the neighbourhood of Tjibeurrem, near Tjibodas (Java), at an altitude of 1575 metres, and at a distance from watercourses. The two last-mentioned species have therefore emancipated themselves from marine conditions to the utmost possible extent, while the two species from Flores were, so to speak, only about to become terrestrial forms, though they had, however, already relinquished existence in sea-water or on the beach, and had exchanged it for life in and beside fresh water.

From these points of view my four species of *Orchestia* afford a not uninteresting contribution to the instances of terrestrial members of this genus with which we are already acquainted. These are *Orchestia sylvicola*, Dana, from the extinct crater of Taiawai, New Zealand, and from woods in the same island, together with *Orchestia telluris*, Bate; *Orchestia tahitensis*, Dana, under leaves and similar objects, at an altitude of 1500 metres in Tahiti; and *Orchestia cavimana*, Heller, at an altitude of 4000 metres upon Olympus (Cyprus), which was rediscovered by Hoek at different localities in Holland, a long way from the sea. Finally, von Martens found *Orchestia humicola* beneath fallen leaves in the vicinity of a wood near Yokohama, while more recently still de Guerne has described * *Orchestia Chevreuxi* from Caldeira de Tayal, in the Azores, at an altitude of 1000 metres above the level of the sea; and Chevreux himself† was able to report this same species from Teneriffe, where he found it in a wood about 500 metres above the sea. De Guerne has already drawn attention to the fact that all these typical terrestrial species of *Orchestia* ‡, which have entirely emancipated themselves from the sea, occur upon islands—as yet with the solitary exception of *Orchestia cavimana*, which Hoek also found in Holland. This remark on the part of de Guerne receives material support from my four species from the Indian Archipelago.

Once more we derive especial interest from the fact that the *Amphipod fauna also of Indian fresh waters is totally different from that of Europe. While Gammaridae are entirely absent, Orchestiidae are only rarely met with, and these were without doubt originally immigrants from the sea.*

The long list of Decapods furnishes various important results.

* Bull. Soc. Zool. de France, 1888, p. 59.

† Loc. cit. p. 92.

‡ We here leave out of the question the fact that genuinely marine species of *Orchestia* are able in many places to withdraw to a distance from the sea, e. g. *Orchestia littorea*.

1. In the first place, out of the twenty genera that I met with in fresh water, only *Telphusa*, with *Geotelphusa* and *Paratelphusa*, and *Atya* occur in fresh water exclusively.

2. The genera *Caridina* and *Palaemon* show only a preponderance of freshwater forms; they contain species that also occur in sea- or brackish water. Among ten species of *Caridina* I found *Caridina Wyckii* and *C. gracilirostris* also in brackish water. Out of twenty species of *Palaemon* from fresh water I took *P. carcinus* also in the sea and in brackish water. In the latter I further obtained *Palaemon sundaicus*, *P. lar*, *P. endehensis*, and *P. latimanus*.

3. We next come to genera that exist equally as well in the sea as in rivers, with an intermediate habitat in brackish water. This has already been recorded by Semper for *Varuna literata*; I also found this animal in these three kinds of water. Besides this species, however, and under similar conditions—*Ocypode cordimana*, *Utica gracilipes*, and ten species of *Sesarma*. Among the latter is one, *Sesarma maculata*, which had already adapted itself to life upon land in moist surroundings; while among four species of *Geosesarma* I met with one species upon land alone, and two others there and also in fresh water. Lastly, *Metasesarma* also belongs to the same division; although I met with it, as also certain species of *Sesarma*, only in fresh water, they will undoubtedly on further search all be found also in the brackish or saline portion of the river-mouths. *Sesarma bidens* I obtained only in sea- and brackish water.

4. Finally we have genera, such as are usually reckoned as being exclusively marine, but which I likewise found in fresh water. Here are to be mentioned two species of *Pseudograpsus*, *Pyxidognathus granulatus*, five species of *Ptychognathus*, *Leander concinnus*, *Penæus monoceros*, and, as very noteworthy, *Alpheus rapax*, *Remipes testudinarius*, and *R. denticulatifrons*. The two latter were met with by my friend A. Wichmann in the River Koinino, in Timor, in fresh water.

The four groups thus indicated, regarded in reversed order, emphasize with sufficient clearness the immigration, still in progress or already complete, of marine Decapods into the rivers. This is obvious at once with respect to groups 3 and 4, but it also applies to *Caridina* and *Palaemon*. With reference to *Palaemon*, I have already pointed out that immigration from the sea is demonstrated to a certain extent by means of the numerous species of Bopyridæ which are parasitic upon these Indian freshwater prawns.

In the list are also included *Cardisoma carnifex*, three

species of *Gelasimus*, and *Sesarma bidens*. These genuine marine animals I obtained, it is true, not in fresh, but still in brackish water. They have consequently arrived to some extent at the first stage of immigration.

Our list thus teaches us that of seventy-six species of Decapods found in fresh water, and therein mentioned, twenty-nine certainly live both in brackish and salt water, and the latter total undoubtedly falls a long way short of the truth. Further, while among Decapods fresh water in Europe contains only *Astacus fluviatilis*, *Telphusa fluviatilis*, Latr., *Pilumnus tridentatus*, Maitland, *Hemicaridina Desmarestii*, Millet, *Leander Edwardsi*, Heller, *Palæmonetes varians*, Leach, and *Troglocaris Schmidtii*, in the Indian Archipelago it yields in all probability considerably more than eighty species.

Consequently with regard to the Decapods also the freshwater fauna of India is as different from that of Europe as it can possibly be; and as to these Decapods, it may be asserted that the majority are distinctly immigrants from the sea. On summing up the results of our discussion the following conclusion may well be pronounced:—

The Crustacean fauna of the fresh water in the Indian Archipelago is composed of two different kinds of elements:

1. Forms of universal occurrence, belonging to the Entomostraca. In comparison with the fauna of Europe this autochthonous freshwater constituent, which has numerous means of dissemination, is but scantily developed. *Apus* and *Branchipus* are absent.

2. Regional or local animals, which are destitute of the aids to dissemination afforded by smallness of body and special arrangement of the branchiæ. It is true that, in so far as they are parasites, they are capable of being transported.

These regional Isopods, Amphipods, and Decapods derive their origin directly or indirectly from the sea, and that by means of immigration, which is also still in progress at the present time, so that even now fresh elements are still continually being added to the freshwater fauna.

This portion of the fauna is entirely different from that of Europe, and the Indian freshwater fauna thus receives an impress of quite another kind *.

* [The remainder of the part is devoted to the description of new species.—TRANSL.]